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- (E) Changes as under *D*, but the names (of Catesby) perhaps to be regarded as Latin vernaculars.
- (F) Changes in accord with the law of priority, but questionable on account of irregularities. These include various Arabic names of Forskal, used for divisions of genera.
- (G) Changes due to so-called preoccupation by earlier, *nearly* identical words. These I think should be rejected as needless, following the opinion expressed in former years by Dr. Jordan and others.
- (H) Questionable cases, similar to *G*.

Whatever we may think of all these cases, we must agree with Dr. Jordan that it is of prime importance to have them decided as soon as possible. The matter concerns all working zoologists, and these, now that they have the facts before them, should endeavor to form and express definite opinions.

The printing and appearance of the book are admirable, but it is unfortunate that the soft paper is unsuited for annotations in ink.

T. D. A. COCKERELL

SPECIAL ARTICLES

THE "RAWNESS" OF SUBSOILS¹

IN his communication to *SCIENCE* for September 21, 1917, Dr. C. B. Lipman has raised the whole question of the relative "rawness," or unproductivity, of subsoils by putting forward the view, based upon his own observations of plant growth upon arid subsoils, that these are but little, if at all, less "raw" or unproductive than those of humid regions. In suggesting that soil investigators do not generally appreciate the facts which support such a view he states the case too mildly. Judging from their published statements they do not even suspect the existence of such facts, emphasizing as one of the most striking characteristics of the subsoils of arid regions the ability of these, when first thrown out of excavations or simply exposed by grading opera-

tions, to support a satisfactory growth of non-leguminous plants as well as of legumes. I am aware of no book or article, previous to that just referred to, in which a contrary view is expressed. This characteristic of arid subsoils, in contrast with those of humid regions, is emphasized in all text-books which refer to the matter at all, as illustrated by the following list of references:

1. "The Soil," by F. H. King, 1904, p. 29.
2. "Soils," by E. W. Hilgard, 1906, p. 163.
3. "The Principles of Soil Management," by T. L. Lyon and E. O. Fippen, 1909, p. 69.
4. "Bodenkunde," by E. Ramann, 1911, p. 527.
5. "Principles of Agricultural Chemistry," by G. S. Fraps, 1913.
6. "Soils, their Properties and Management," by T. L. Lyon, E. O. Fippen and H. O. Buckman, 1915, p. 82.
7. "Die Bodenkunkolloide," by P. Ehrenberg, 1915, p. 164.

The view that the characteristic subsoils of arid regions are lacking in rawness appears to be based almost entirely upon the observations of the late Dr. E. W. Hilgard, who, in 1892, first called attention to the matter, mentioning the following example:

In the case of a cellar 7 to 10 feet deep, near Nevada City, California, the red soil-mass dug out was spread over part of a vegetable garden close by, and, as a venture, the annual vegetables—tomatoes, beans, watermelons, etc.—were sown just as usual. They not only did well, but better than the portions not covered, which had been cultivated for a number of years and were somewhat exhausted thereby.²

F. Wholtmann, of Halle, who in the early years of the present century made several visits to California, later expressed the same view, but it is not clear to what extent his conclusions were based upon his own observations, he having discussed the matter with Hilgard while in America. The common tendency to take Hilgard's conclusions on such matters as the final word is well illustrated by Ehrenberg, of Göttingen, who, in his very recent book included in the above list, mentions that

² U. S. W. B. Bul. 3, p. 19.

¹ Published with the approval of the Director as Paper No. 96, of the Journal Series of the Minnesota Agricultural Experiment Station.

during his many years of investigation he (Hilgard) had become the best judge of the differences of soils of humid and arid regions (p. 164).

This remarkable property of arid subsoils, repeatedly emphasized by Hilgard in his various publications and mentioned in the works of other investigators from the time of the appearance in 1904 of the late Dr. F. H. King's "The Soil" (p. 29), must surely have excited the interest of botanists, geologists and irrigation engineers as well as of agricultural investigators, not only in California, but also in arid lands on other continents. Yet until the present observations of Dr. Lipman no word of criticism has appeared.

The accepted view, in brief, has been that on the freshly exposed subsoils in humid regions inoculated legumes as well as non-leguminous plants fail to make a satisfactory growth, one at all comparable with that on adjacent surface soils, while under similar conditions in arid regions the subsoil may be expected to show practically as good a growth as adjacent surface soil. The question of the *maintenance of productivity* in the case of the non-legumes on the arid subsoils has not been raised, interest centering upon the initial performance of the freshly exposed material. With the humid subsoils the "rawness" understood has not been absolute sterility, as Lipman appears to assume, but a low productivity. Lipman recognizes and confirms by his own observations the productivity of arid subsoils toward inoculated legumes, but denies that non-legumes make any satisfactory growth on these. While recognizing the characteristic sterility toward non-legumes of subsoils of humid regions he doubts the existence of any proof that inoculated legumes will not grow on humid subsoils. He uses the term "grow" but, as the whole question is whether the plants "thrive" and not whether they are barely able to make a weakly, stunted growth, it is desirable to discuss the matter as though "thrive" had been employed. In short, he considers "the lack of available nitrogen probably is sufficient to account for the rawness of subsoils" of both humid and arid regions toward non-leguminous plants and questions

the existence of any rawness in the case of inoculated legumes.

While the views current upon the subsoils of arid regions may be due to Hilgard alone, those upon the subsoils of humid regions are founded upon the observations of numerous investigators in Europe as well as in America. Many of these may antedate 1886, the year in which Hellriegel established the rôle of symbiotic bacteria in the growth of legumes, but in the thirty years that have since elapsed it is surprising that none from among the hundreds of agricultural investigators in humid regions has called attention to the earlier false explanation, if the failure of such crop plants on exposed subsoils were due only to the lack of inoculation. The universally accepted idea of the rawness of humid subsoils in general is based not upon pot experiments or upon the growth of plants upon subsoils exposed by grading operations or thrown up from excavations, but upon observations of the growth of the crops in fields where the plow had unwisely been run a few inches below the usual depth of cultivation, with the result that the fields for years after had shown in their lessened crop returns the unproductivity of the subsoil brought to the surface. In view of the almost universal distribution of red clover in western Europe and in the humid states of this country the necessary bacteria could rarely have been missing. If the rawness were due simply to lack of inoculation such deeply plowed fields might be expected to have shown, when sown to small grains with the usual accompaniment of clover seed, a remarkably vigorous growth of the legume accompanying the failure of the cereal, a phenomenon which could scarcely have escaped mention.

In the very article by Alway, McDole and Rost,³ which has called forth the statements of Lipman, such a phenomenon has been described. The field of 5 acres is in a railway cut near Blair, Nebraska, where about 17 years previously the surface material had been removed to an average depth of 25 feet. It had never been manured or seeded to a legume crop, but for several years had been planted to

³ "Soil Science," Vol. 3, p. 9, January, 1917.

corn and sorghum without producing a satisfactory crop, and, in 1912, the first year it was visited by the authors, the crop of corn was not worth gathering. The next spring the west half of the field was seeded to alfalfa alone, but the east half to oats with alfalfa. As at both ends the field extended beyond the cut so as to include undisturbed ordinary black surface soil there was a chance to compare the growth of the two crops on the exposed yellow subsoil with that on ordinary surface soil. The whole of each half had been seeded by the same man, at the same time and with the same seed. When visited in July the alfalfa on both was found fully inoculated; on the portion seeded without nurse crop it was practically as good as on the black surface soil, but on the other half of the field marked differences were shown by subsoil and surface soil. The oats on the former were yellowish-green in color, with short straw and poorly filled heads, while on the latter they were dark green and tall with well filled heads; the alfalfa on the exposed subsoil showed a good stand and the plants were almost as large as where seeded without a nurse crop, but on the surface soil they were few in number and small, evidently having succumbed to the oats in competition for moisture.

In his communication Dr. Lipman appears to have made the mistake of considering the Nebraska subsoils involved in our field observations as semi-arid. We regard them as strictly humid as pointed out in earlier papers of the series. Further, he considers them representative of all Nebraska subsoils; a view for which there appears no justification. They represent only the loess subsoils of eastern Nebraska. He is in error in stating that we claim legumes will not grow on subsoils of humid regions. On the contrary, while we pointed out that the "rawness" of humid subsoils toward legumes as well as non-legumes is generally assumed by soil investigators, the burden of our paper was to prove that in the case of the loess subsoils of the humid portion of eastern Nebraska there was no rawness toward inoculated legumes. We offered no evidence and made no claims as to the raw-

ness of any subsoils other than those of the loess region of Nebraska. A forthcoming paper by Mr. P. M. Harmer, of this laboratory, will deal with the growth of alfalfa on subsoils from widely separated points in Minnesota, a humid state.

In one of his last articles (1912) Hilgard mentioned a heap of subsoil at Berkeley, excavated from a depth of over twelve feet, which had become covered with a thick stand of grasses and weeds of all kinds. Lipman suggests that this may have consisted of surface material which had been buried in previous cutting operations. A very similar, but evidently distinct example is furnished in a letter which the writer received from Hilgard in May, 1907.

Last winter a foot-ball field was excavated here (Berkeley) to a depth of 16 feet at one end, and a bank of yellow-brown clay was thrown up on the surface 6 feet high. Now I find this clay almost covered with a growth of the usual weeds whose seeds were blown there by the high winds. Sherry and dock are most luxuriant, but oats, barley and ray grass are also as common as on the surface soil adjacent. I remember a similar clay pile at my old home in Illinois where nothing ever grew in ten years after it was dug out of the cellar.

Doubtless there are many in California and in other arid lands who have valuable observations upon the subject which should be published. No one appreciated the value of such more than did Hilgard, who, in the letter quoted above, inquiring as to the growth of plants on exposed subsoils in western Nebraska, wrote:

Such observations as that are just as valuable as if a special expedition had been sent out by the Carnegie Institute. Please do not forget to have them gathered up while your state is young, for they will be much more difficult latter. Field observations under normal conditions by experienced investigators are far more cogent than any number of vegetation or pot experiments.

It is to be hoped that any extant records of such observations on California and other arid subsoils will soon be published.

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